

# Intramuscular Fat and Conception in Cows (*Bos taurus*)

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**ABSTRACT.** Real-time ultrasound intramuscular fat (IMF), back fat (BF), and rump fat (RF) measurements were obtained at or near breeding and compared to conception status in beef cows (*Bos taurus*). The objective of this experiment was to determine if real-time ultrasound IMF measurements are correlated with conception in beef cows. The study included 207 cows that were being used in an estrus synchronization program. Ultrasound measurements were collected at the first timed artificial insemination session. Collection of IMF involved two images: the upper quip (UQ) proximal to the skin and the lower quip (LQ) deeper in the muscle. RF was correlated ( $P < 0.01$ ) with BF and UQ measurements. However, BF measurements did not appear to be correlated ( $P > 0.20$ ) with LQ or UQ. The BF, RF, UQ, calf birth weight and postpartum interval measurements did not merit inclusion in the model based on a log likelihood test ( $P > 0.05$ ). The LQ measurement was positively correlated with the probability that the cow became pregnant ( $P = 0.03$ ). In the range of lower quip values from 0 to 10, the probability of successful pregnancy increased approximately five percent for a five-unit increase in the LQ value. For LQ values in the range of 10-15, the probability of successful AI increased approximately 2.5 percent for a five-unit increase in the lower quip value. The log likelihood test value for UQ was close ( $P = 0.06$ ) to being significant and merits further investigation.

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## INTRODUCTION

Cows (*Bos taurus*) require adequate energy stores to supply their basal metabolism, growth, lactation, and reproduction function (Ayres and others, 2009). Visual body condition scores are a fast and easy way to estimate subcutaneous fat deposits. Previous studies with real-time ultrasound of subcutaneous fat thickness at the 12 to 13<sup>th</sup> rib region or back fat (BF) and rump region or rump fat (RF) have been used to estimate body energy reserves of animals (Ayres and others, 2009; Schroder and Staufenbiel, 2006). All these methods can be useful but do not provide information on intramuscular fat (IMF) status.

Intramuscular fat is generally deposited after an animal has created most of its muscle (Wertz and others, 2001). In forage-based systems, animals must have sufficient nutrients to maintain their organ function before bone or muscle growth can occur, and these must occur before fattening can occur. Studies using real-time ultrasound (Nash and others, 2000) demonstrate that IMF deposition proceeds in a non-linear manner across time-on-feed.

Intramuscular fat status, as determined by real-time ultrasound, has not been investigated for its impact on conception. Differences in predicted and actual reproductive performance may be more fully explained

with knowledge of IMF status. The objective of this experiment was to determine if real-time ultrasound IMF measurements are correlated with conception in beef cows.

## MATERIALS AND METHODS

### Animal Breeding Methods

The study included 207 Angus and Angus-cross cows used in an estrus synchronization program during one year. All cows were lactating for a current calf. The estrus synchronization program was an intravaginal progestin or CIDR (Pfizer, New York, NY) with strategic use of prostaglandin and gonadotropin releasing hormone. Artificial insemination (AI) was at a fixed time and by a single technician. Bulls were then placed with the cows. The bulls remained with the cows for approximately 25 days. The cows have been used in estrus synchronizations programs for three years prior to this study. Palpation for pregnancy status occurred approximately 45 days after breeding.

### Ultrasound Site Preparation

Real-time ultrasound measurements were collected at the timed AI sessions. A Classic Scanner-200 (CS-200), equipped with a 3.5-MHz 18-cm transducer with 128 crystals (Classic Medical Inc., Tequesta, FL) was used to measure BF, RF, and IMF. Excess dirt and debris were removed by vigorous brushing and hair was clipped from each area to be scanned. Once the scanning site was determined by palpation, each animal was scanned on

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the right side to collect images. The right side was used because the AI workers were operating on the left side of the chute. Vegetable oil was used as a couplant to obtain adequate acoustical contact with the animals.

### Subcutaneous Fat Measurements

Transversal scans between the 12<sup>th</sup> and 13<sup>th</sup> rib were performed to measure BF. A standoff guide (Animal Ultrasound Services, Ithaca, NY) was used to ensure proper contact with the curvature of the animal's back when recording images for BF. Images for BF were measured at a position three-fourths the distance from the medial end of the longissimus dorsi muscle to the lateral end. While skin thickness is sometimes included in subcutaneous fat measurements, it was subtracted from the total values obtained in this study to illustrate only the subcutaneous fat thickness for BF and RF (Ayers and others, 2009).

Subcutaneous RF was measured immediately below the juncture of the gluteus medius and biceps femoris muscles between the tuber coxae (hookbone) and tuber ischii (pin) bones with the transducer placed approximately 2.5 cm dorsal to the hookbone and parallel to the backbone (Realini and others, 2001). A standoff guide was not used to measure RF.

### Intramuscular Fat Measurements

The Quality Ultrasound Index Program (QUIP) software (Version 2.6) of Pie Medical, Netherlands was used to estimate IMF. Ultrasound IMF score was estimated based on the work of Gresham (1997, 2001). A calibration phantom (Classic Medical, Inc., Tequesta, FL) for the probe was used to calibrate the CS-200 before the scanning event. Guidelines for calibration are described by Gresham (1997).

A longitudinal scan at the 13<sup>th</sup> rib and first lumbar vertebrae without a standoff guide was done to predict IMF. The probe was placed in a plane parallel to the mid-line of the animal at a point approximately the midpoint of the longissimus dorsi muscle. IMF measurements with this software involve two different images in the dorsal and ventral area of the longissimus dorsi muscle. The software utilizes image pixels of various shades within each region to estimate IMF. The image of the longissimus dorsi muscle in the dorsal region is called the upper quip (UQ). The initial analysis box placement is approximately 1.25 cm below the backfat layer, above the area between the 13<sup>th</sup> rib and first lumbar vertebrae plus the area above the first lumbar vertebrae. After recording the UQ, the operator used a track ball

to scroll the QUIP box down or to the ventral region of the longissimus dorsi muscle image and the LQ value was calculated. The software uses depth of the longissimus dorsi muscle, UQ, and LQ values to calculate a predicted intramuscular fat composition. The software was programmed to characterize live muscle tissue in beef animals up to 24 months of age. Therefore, this study utilized the software outside of its indicated range and proposed purpose of estimating IMF in market cattle and prediction of IMF in young, growing cattle. The measurements in the current study do not indicate actual percent IMF but were used to compare values of UQ and LQ to conception results.

### Statistical Analysis

Pregnancy status was based on palpation after breeding. In addition to the ultrasound measurements, postpartum interval, birth weight and sex of current calf were included as variables. The statistical analysis methodology used in this study was a multiple logistical regression model. All the variables were used to model pregnancy status. Then all pairs of independent variables involving the four variables of greatest interest (BF, UQ, LQ, and RF) were used in factorial models. A log likelihood test ( $P = .05$ ) was used to determine if more complex models were appropriate (SAS, 2005). The estimates in the output were the log odds. That is, if  $p$  is the estimate probability of being not pregnant then the estimate is  $\log(p/1-p)$ .

## RESULTS

The BF ranged from 0.03 to 1.78 cm with the average of  $0.43 \pm 0.03$  cm; the RF ranged from 0.03 to 1.50 cm with an average of  $0.48 \pm 0.03$  cm. The UQ ranged from 1.03 to 21.15 with an average of  $11.21 \pm 0.66$ ; and the LQ ranged from 0.92 to 19.03 with an average of  $7.67 \pm 0.58$ .

All the variables were used to model non-pregnant against pregnant. The most interesting models were those that included either UQ or LQ. Based on Pearson square analysis, LQ and UQ measurements were correlated ( $P < 0.01$ ) with each other (Table 1). The RF measurement was correlated ( $P < 0.01$ ) with the BF and UQ measurement. However, BF measurements did not appear to be correlated ( $P > 0.20$ ) with the LQ measurements. While birth weight of current nursing calf ( $49.0 \pm 1.4$  kg) was correlated ( $P < 0.05$ ) with the ultrasound measurements, the relationships were not particularly high ( $r^2 = 0.247$  to  $-0.321$ ). Postpartum interval ( $82.85 \pm 6.04$  days) was not correlated ( $P > 0.05$ ) with ultrasound measurements or birth weight of nursing calf.

The BF, RF, UQ and birth weight of calf did not merit inclusion in the model based on a log likelihood test ( $P > 0.05$ ). However, the LQ measurement affected the probability of pregnancy ( $P = 0.03$ ). The logistic regression model was rerun with just the LQ measurement as the predictor variable. Based on this model, the probability of successful pregnancy as a function of the LQ measurement was calculated. It appeared that higher LQ values have a positive effect on the probability of successful pregnancy. Cows that did not conceive had an average LQ of 5.8 with a minimum of 1.08 and a maximum of 16. Cows that did conceive had an average UQ of 7.8 with a minimum of 0.92 and a maximum LQ of 19. To further illustrate the point of LQ and pregnancy the LQ values were ranked from highest to lowest and pregnancy rate was calculated (Table 2). Quartile LQ values ranked from highest to lowest had conception rates of 85, 85, 92, and 96 percent, respectively. Conception values when UQ were split into quartiles from lowest to highest were 83, 87, 94, and 94 respectively. In the range of LQ values from

0.9 to 10, it appears that the probability of pregnancy increased approximately five percent for a five-unit increase in the LQ value. That is, within this range, the probability of pregnancy increases approximately one percent for each unit increase in the LQ value. For LQ values in the range of 10-15, the probability of a successful pregnancy increased approximately 2.5 percent for a five-unit increase in the LQ value. Or in this range, the probability of pregnancy increased by 0.5 percent for each unit increase in the LQ value.

## DISCUSSION

Cows require adequate energy stores for reproduction function. Visual body condition scores are an estimate of subcutaneous fat deposits. Broring and others (2003) found visual body condition score to be positively related to ultrasound BF measurements. Yokoo and others, 2008 observed RF means were higher than BF means at various ages. A cow could visually appear to have adequate levels of BF or RF, but could be using IMF to compensate for energy shortages. This situation could

**Table 1**  
Pearson correlations of ultrasound measurements, birth weight of previous calf and postpartum interval in beef cows

	Back Fat	Upper Quip <sup>1</sup>	Lower Quip	Rump Fat	Birth Fat
Quip Upper	0.068 <sup>2</sup> 0.244 <sup>3</sup>				
Lower Quip	-0.067 0.000	0.859 0.000			
Rump Fat	0.657 0.000	0.237 0.002	0.044 0.580		
Birth Weight	0.247 0.000	-0.269 0.000	-0.321 0.000	0.156 0.089	
Post Partum Interval	0.102 0.164	-0.048 0.511	-0.095 0.198	0.080 0.488	-0.091 0.216

<sup>1</sup>QUIP -- Quality Ultrasound Index Program, Pie Medical's proprietary system for estimation of intramuscular fat.

<sup>2</sup>Pearson correlation

<sup>3</sup>Probability

**Table 2**  
**Pregnancy rates of beef cows based on ultrasound LQ values**  
**split into quartiles from lowest to highest LQ**

Quartile values	Pregnancy	LQ <sup>1</sup>	UQ <sup>2</sup>	BF <sup>3</sup>	RF <sup>4</sup>	BW <sup>5</sup>	PPI <sup>6</sup>
LQ1	85+36.4	3+0.9	6+2.5	0.2	0.2	71	88
LQ2	85+36.2	6+1.9	9+2.7	0.2	0.2	61	82
LQ3	92+33.8	9+2.8	13+9.1	0.2	0.2	50	73
LQ4	96+31.1	13+4.1	16+4.8	0.2	0.2	45	73

<sup>1</sup>Lower Quip <sup>2</sup>Upper Quip <sup>3</sup>Back Fat <sup>4</sup>Rump Fat <sup>5</sup>Birth Weight of Calf <sup>6</sup>Postpartum Interval

at least partially explain why some cows do not breed when adequate visual body condition score indicates they should have a successful mating.

The initial analysis identified a high correlation among several of the primary predictor variables (ultrasound measurements) and demonstrated the possibility of a statistically significant relationship of the probability of a successful pregnancy and the LQ measurement. The UQ could be still another IMF measurement of value and merits further investigation. The log likelihood test value for UQ was close ( $P = 0.06$ ) to being significant.

There has been much research on the use of ultrasound for evaluating body composition and intramuscular fat in grain-fed market cattle. However Aass and others (2006) and the current study are the only experiments involving cattle with less than four percent IMF and Aass and others (2006) used bulls not cows. A visual observation of body condition remains a valuable and economical tool for commercial beef producers and is found to relate to subcutaneous fat. Data has been collected on the amount of live body weight needed to alter body condition score of cows (Tennant and others, 2002). Further work is needed on how this is reflected in ultrasound BF measurements and the amount of IMF. Future research projects on reproduction and cow body condition should include a component of ultrasound scanning for IMF.

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